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# MODELLING TRANSPORT SYSTEMS WITH FRAM: FLOWS OR FUNCTIONS?

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# Models with methods



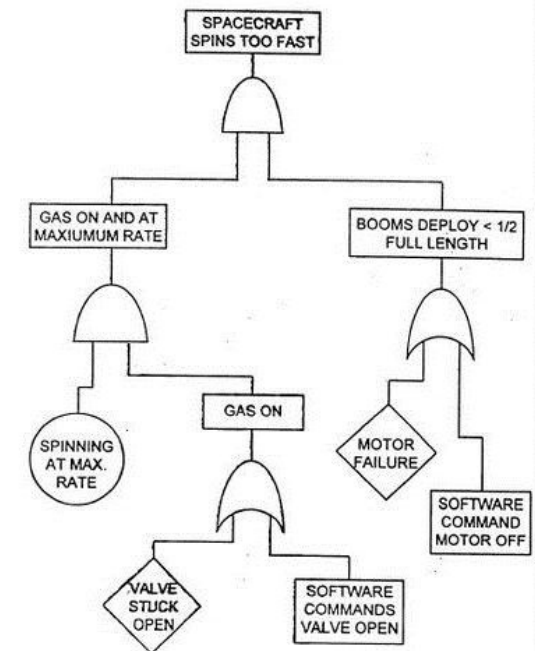
An ANALYSIS is a way (method) of studying the nature of something or of determining its essential features and their relations.

An analysis inevitably involves some assumptions (a model) about how that something happens.

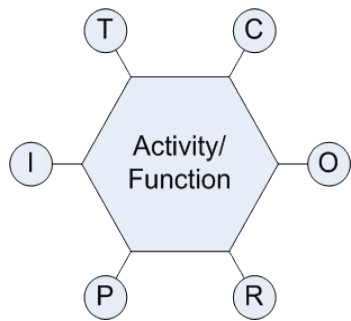
A METHOD is a systematic manner or procedure, an orderly or logical way of doing something to achieve a desired end in a reliable manner.

A MODEL is a simplified, systematic description of an object or phenomenon that represents important structural or functional characteristics. Models are often **structural**, and can be material, symbolic, mathematical, or computational.

The model defines the method to use and how to use it, but also sets the limits of the method.



# Method without model



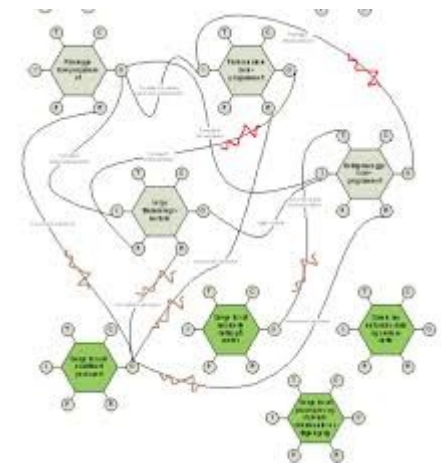
## Functional Resonance Analysis Method (FRAM)

A method to produce a representation of an activity (an operation, a service) in terms of the functions needed to carry out the activity and the ways in which they are coupled (mutually dependent).

FRAM is based on four principles (assumptions) but does not include a model as such.

The FRAM analyses a phenomenon in order to build a **functional model**.

The functional model can then be analysed with regard to a specific purpose (event analysis, consequence analysis, what-if-analysis, sensitivity analysis, etc.)



# The four principles of the FRAM

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## I The principle of equivalence of successes and failures.

*Things that go right and things that go wrong happen in basically the same way. There are no special causes that only work for failures.*

## II The principle of approximate adjustments.

*People always have to adjust what they do to match the situation. This kind of performance variability is inevitable, ubiquitous, and necessary.*

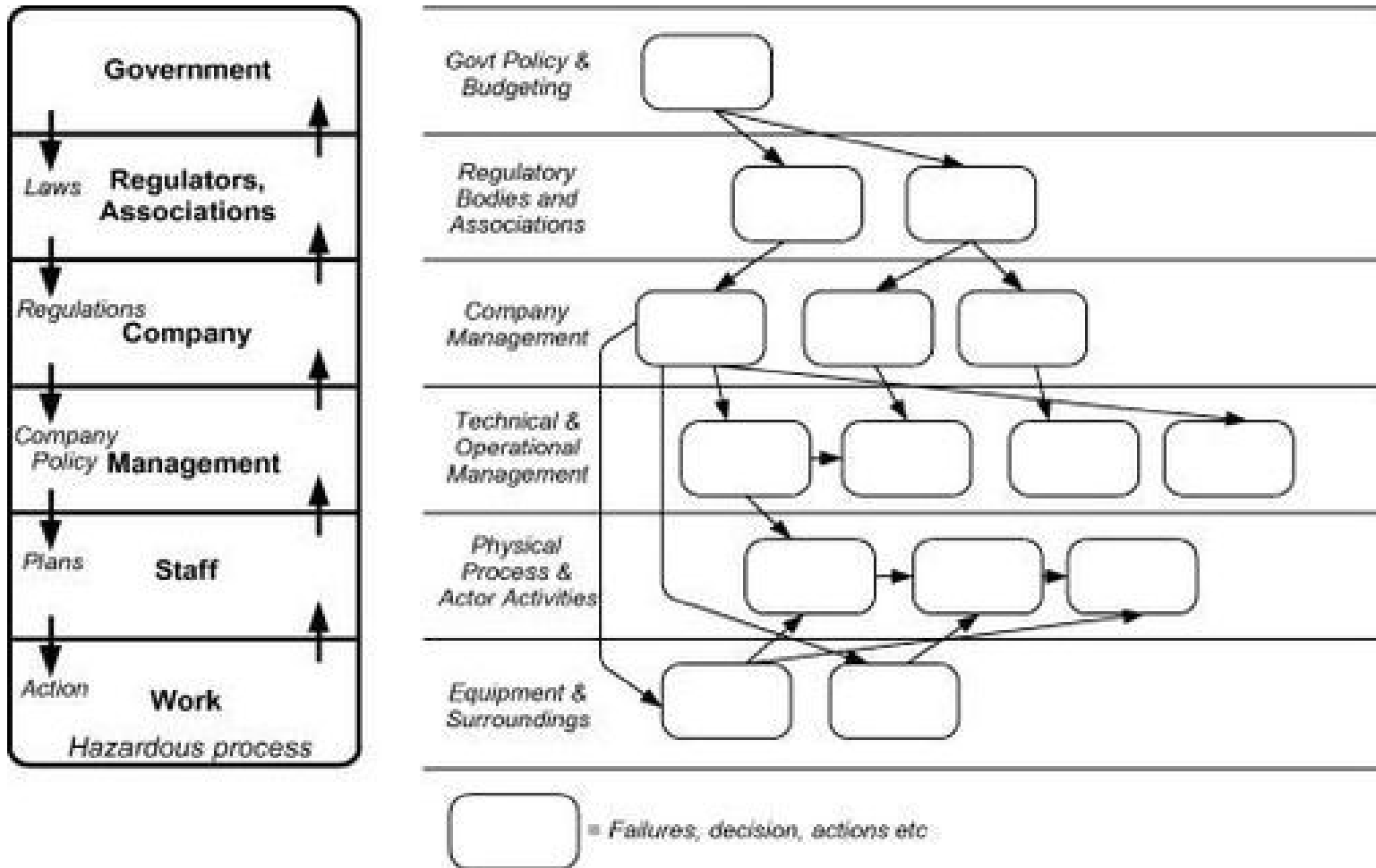
## III The principle of emergence.

*Performance variability may combine in unexpected ways, leading to outcomes that are disproportionately large (non-linear effects). An outcome is emergent if it neither can be attributed to nor explained by (mal)functions of the system.*

## IV The principle of functional resonance.

*Functional resonance is the detectable signal that emerges from the unintended combination of the variability of many signals. Functional resonance is an alternative to linear causality.*

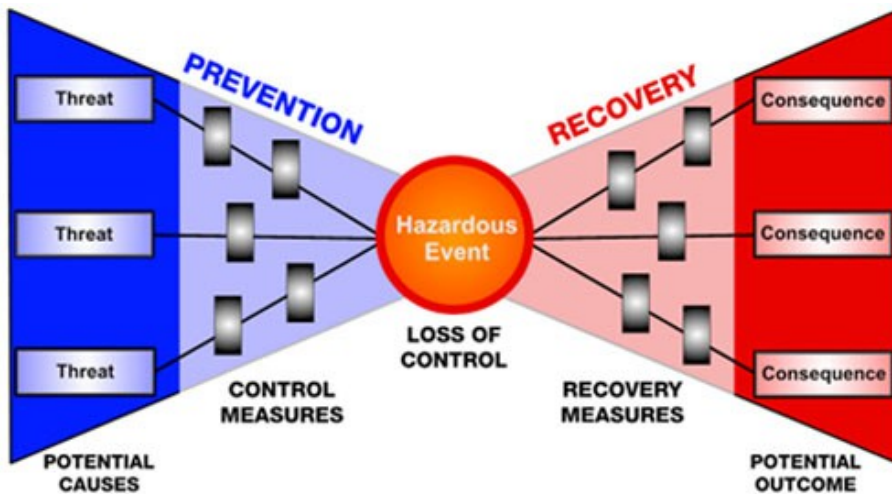
# Methods usually “hide” their models



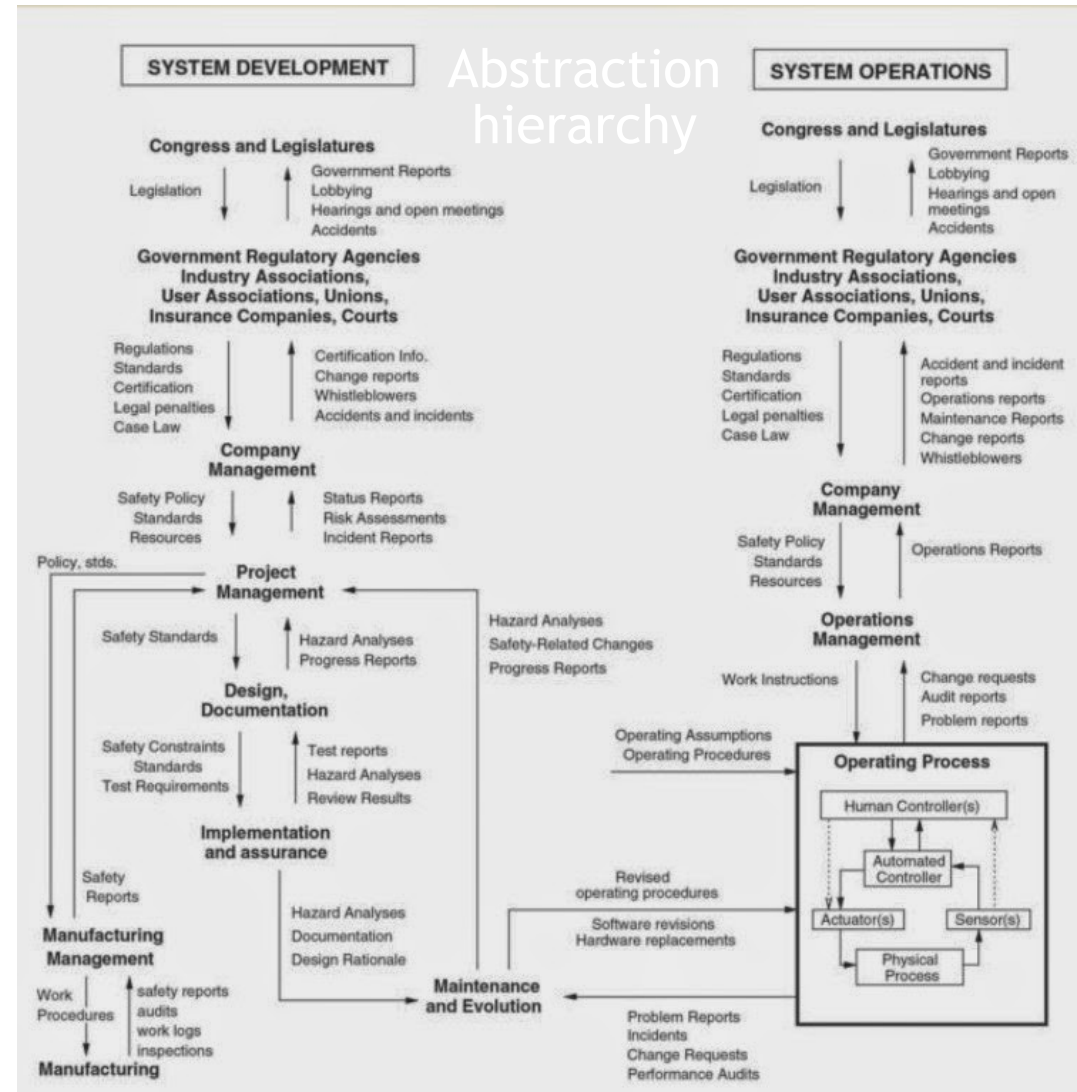
## AcciMap - The abstraction hierarchy (Rasmussen, 1985)

# Methods usually “hide” their models

Bowtie - combined fault tree and event tree



STAMP (Leveson, 2003)  
Systems Theoretic Accident  
Model and Processes



# What is a function?

In a mathematical function, one quantity (the argument or the input) completely determines another quantity (the value, or the output).

$$Y = F(x)$$

If some prescription adds one and only one element of a set  $\{y\}$  to every element of set  $\{x\}$ , then  $y$  is called a function of  $x$ .



In engineering, a function refers to a specific process, action or task that a system is able to perform.

The function of a calculator, the function of a windmill, the function of a pump, etc. etc.

In human factors, a function refers to the task or activity – or set of tasks or activities - that must be done to produce a certain outcome. A function describes what people – as individuals or collectives – or organisations have to do to achieve something (an aim).

Functions are the **means** that are necessary to reach stipulated **goals**.



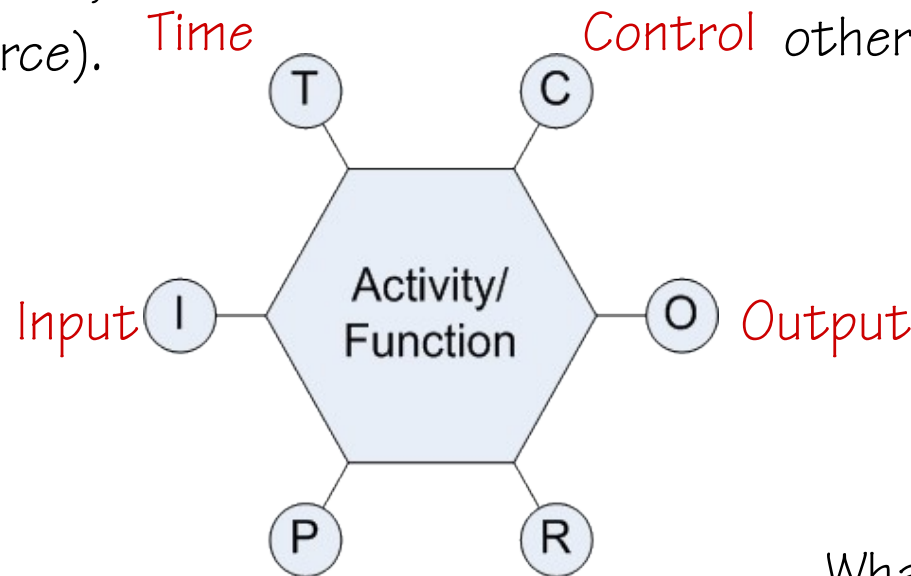
# Describing a FRAM function

Temporal aspects that affect how the function is carried out (constraint, resource).

The supervision or regulation of the function. E.g., plans, procedures, guidelines or other functions.

That which activates the function and/or is used or transformed to produce the output. Constitutes the link to upstream functions.

The result of the function. Provides the links to downstream functions.

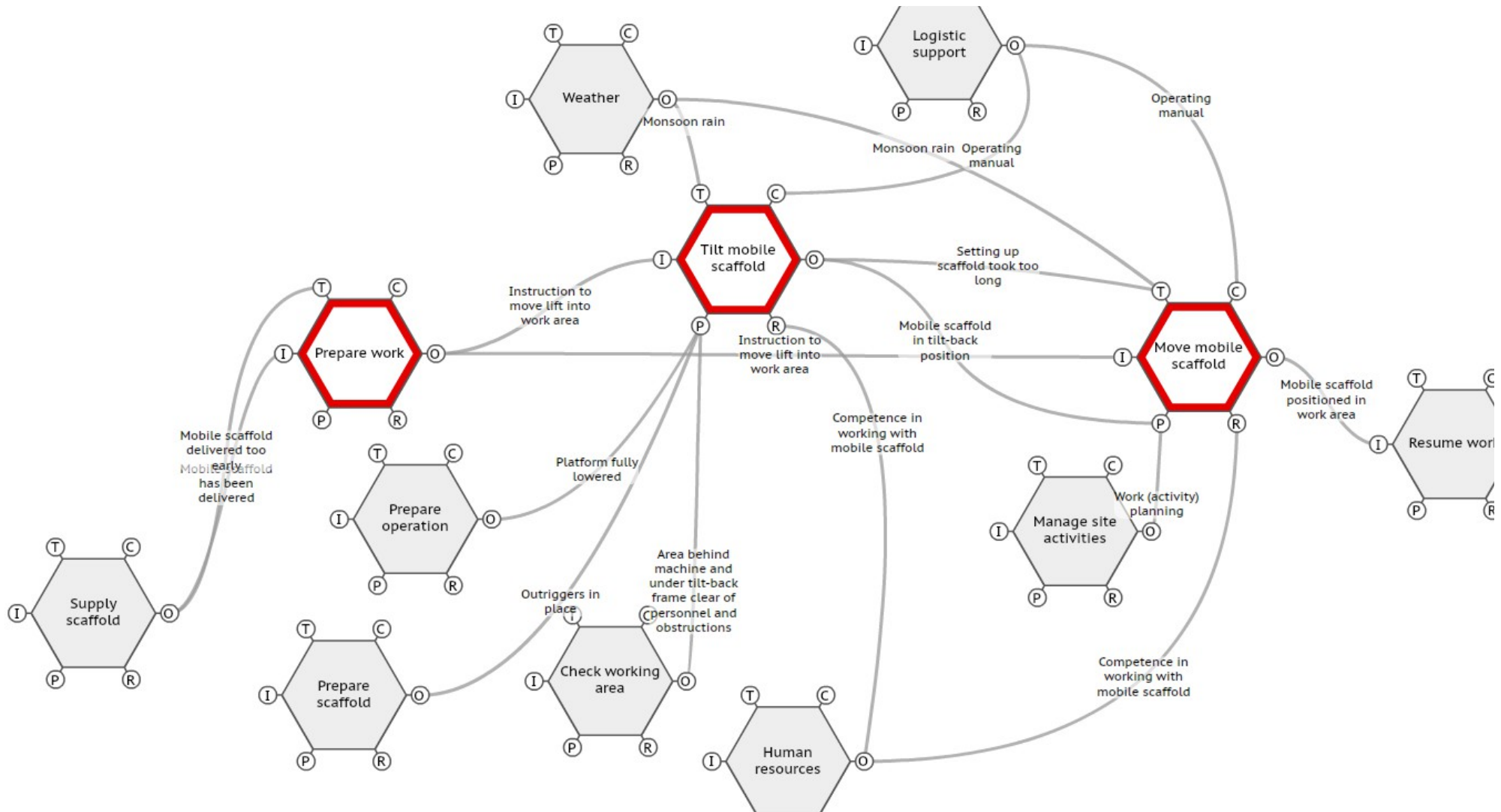


System conditions that must be fulfilled before a function can be carried out.

What is needed or consumed when the function is active (matter, energy, manpower, etc.).



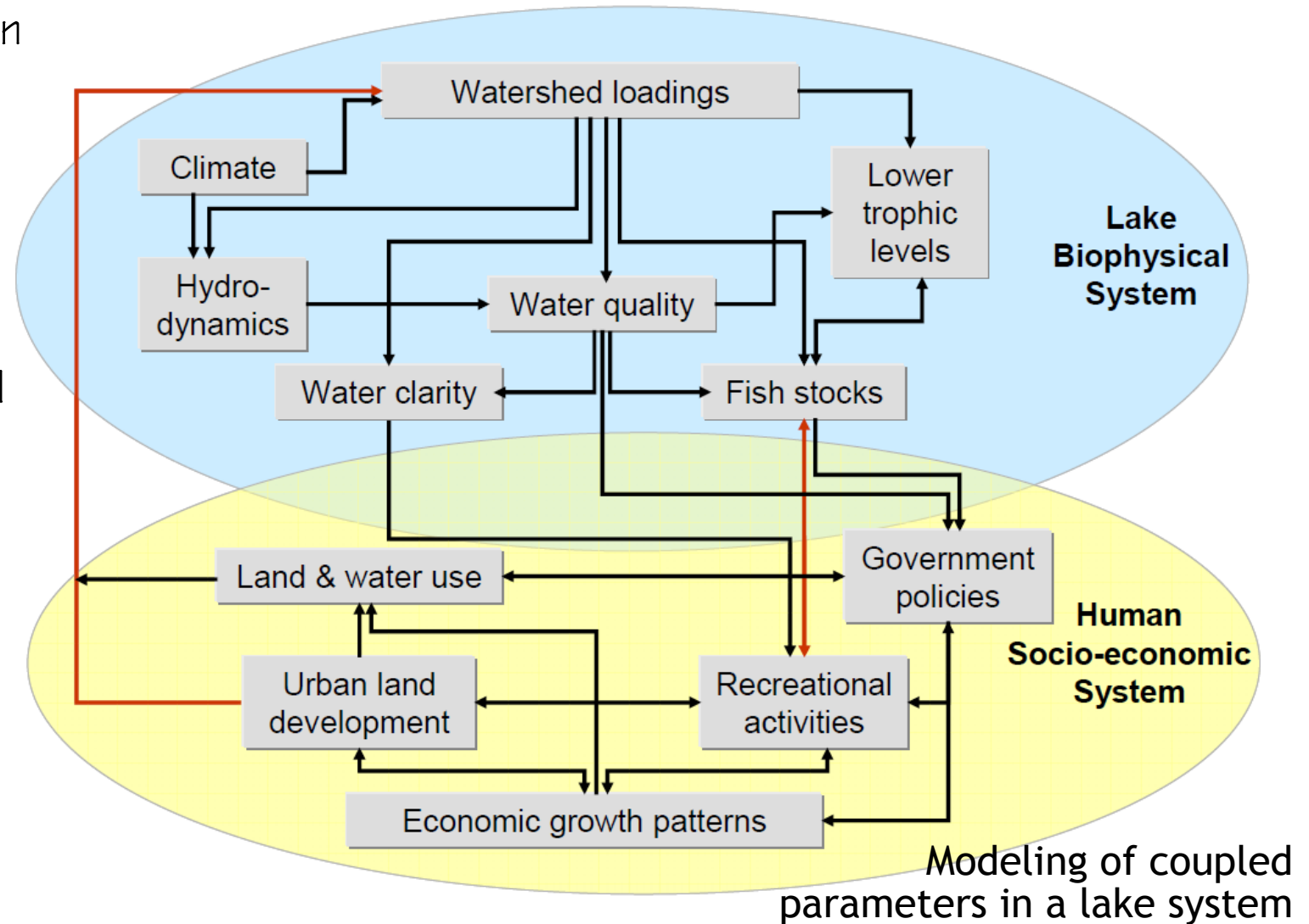
# Example of a FRAM model



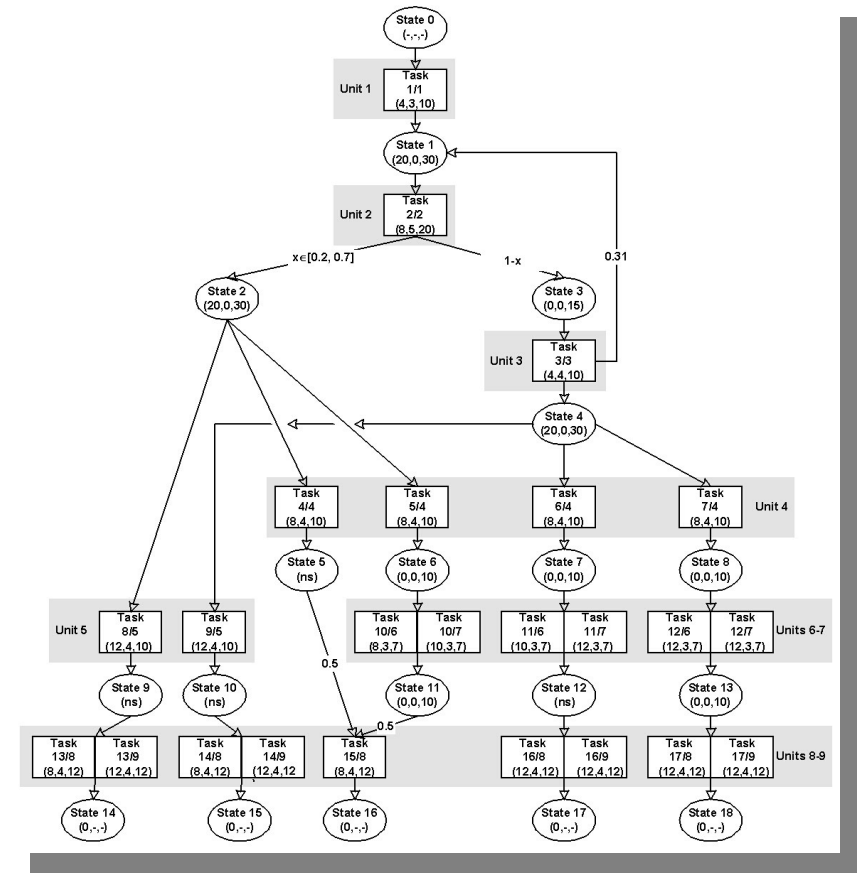
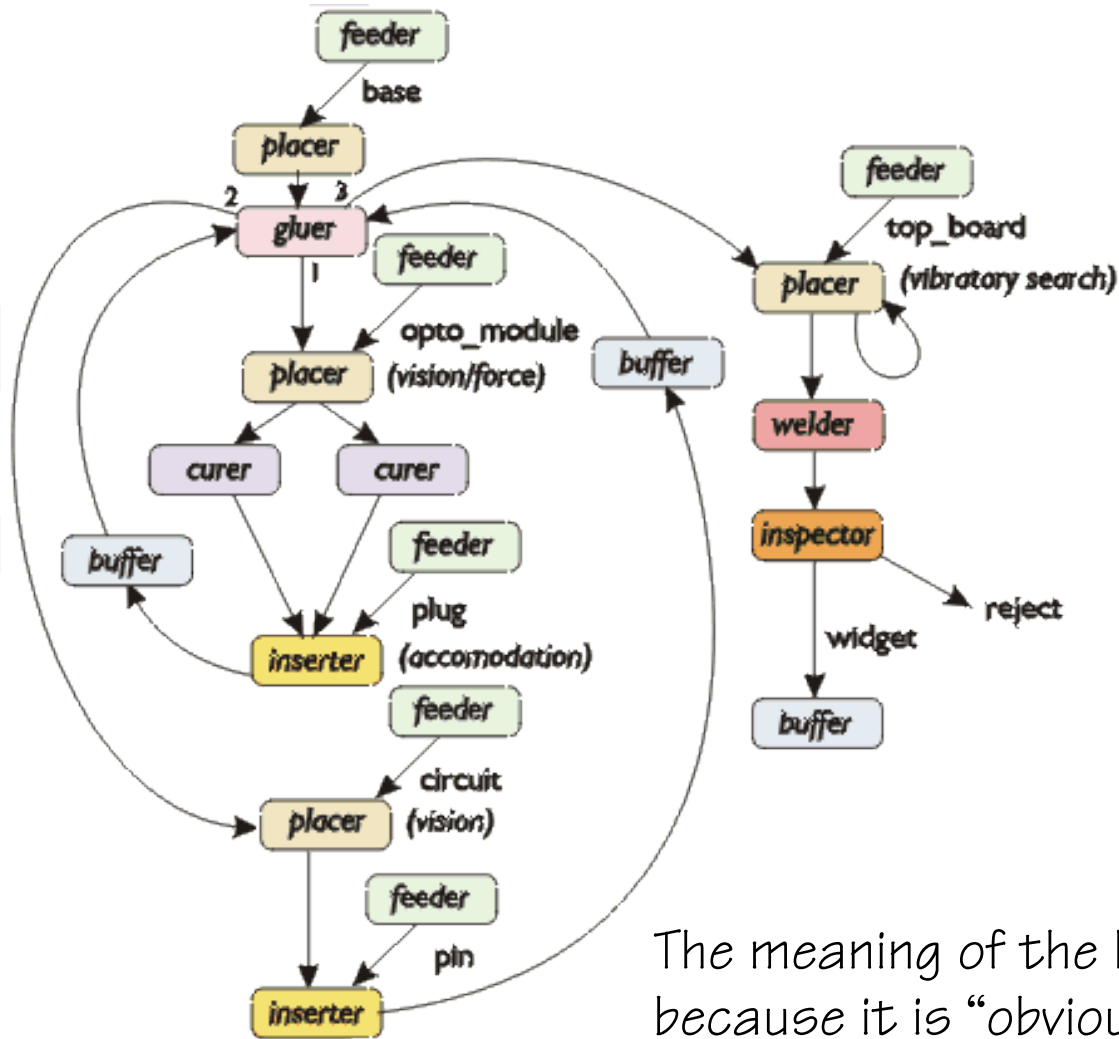
# Boxes and lines (arrows)

Models usually contain boxes (objects) connected by lines / arrows (links).

The model often represents a flow, and the links represent temporal or logical relations.

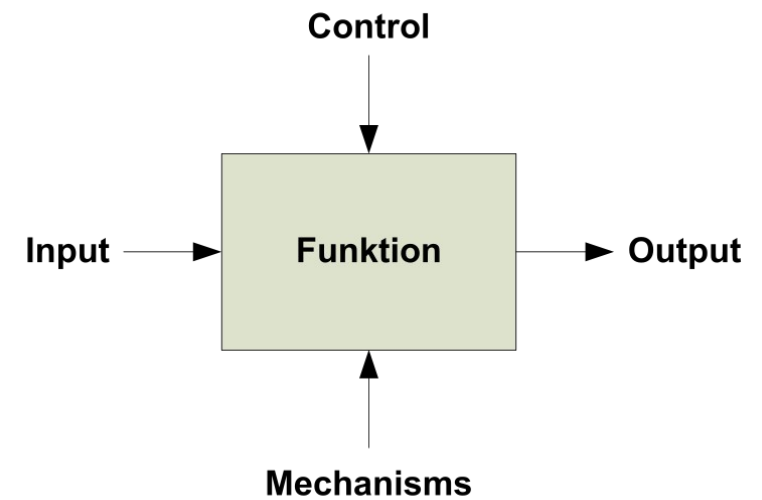
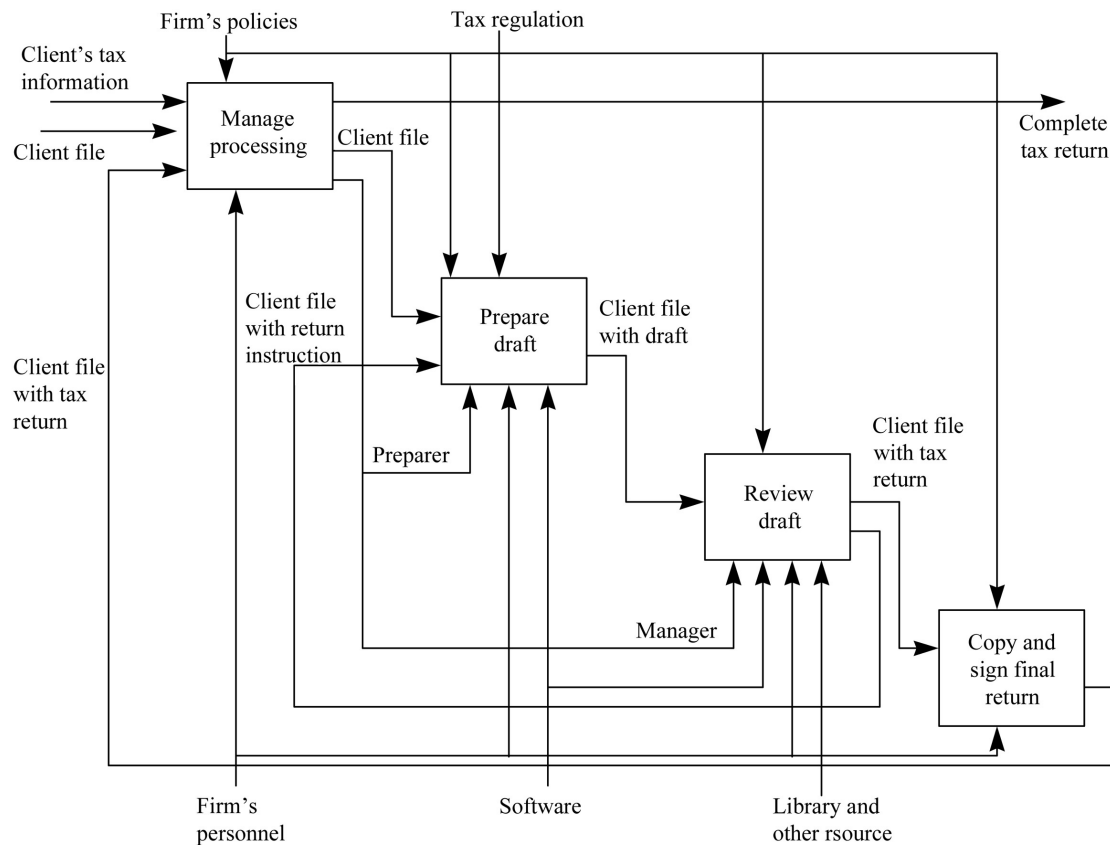


# Boxes and lines



The meaning of the lines (semantics) is usually implicit because it is “obvious” to the user.

# Boxes and meaningful lines (SADT)

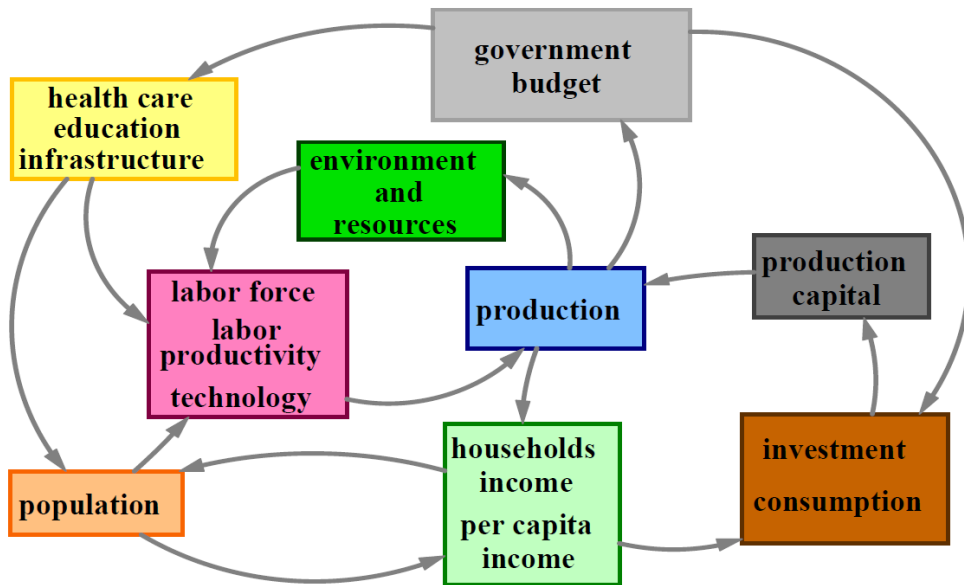


The lines represent well-defined relations

Source: Congram and Epelman (1995)

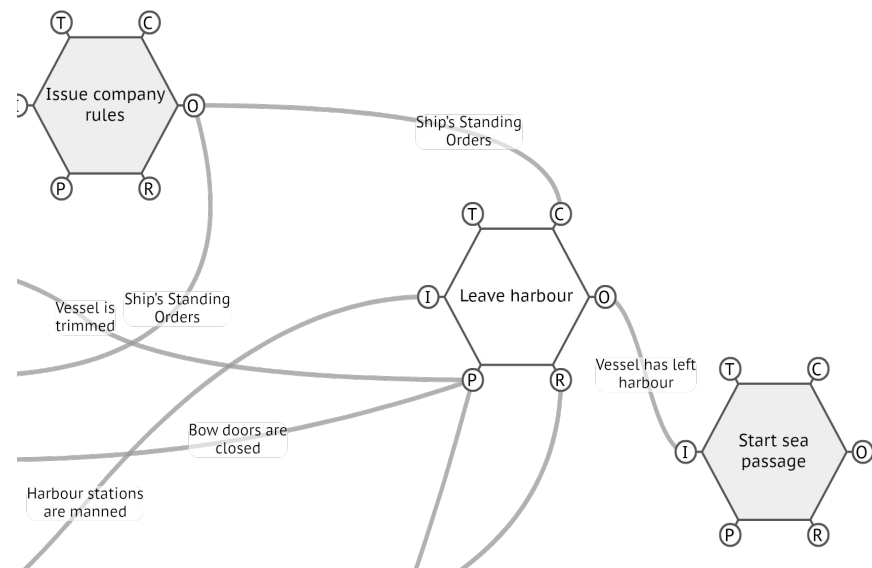
The SADT is a flow model. The lines between boxes are predefined and fixed.

# “Drawing” the connectors



In a FRAM model, the connections between functions must be explicitly defined by describing the aspects. If this is done correctly, the connection will be drawn automatically. It cannot be done manually.

The usual practice when building a model of something is to add “named” boxes whenever needed and then to draw lines between them.



# Identifying Functions: General

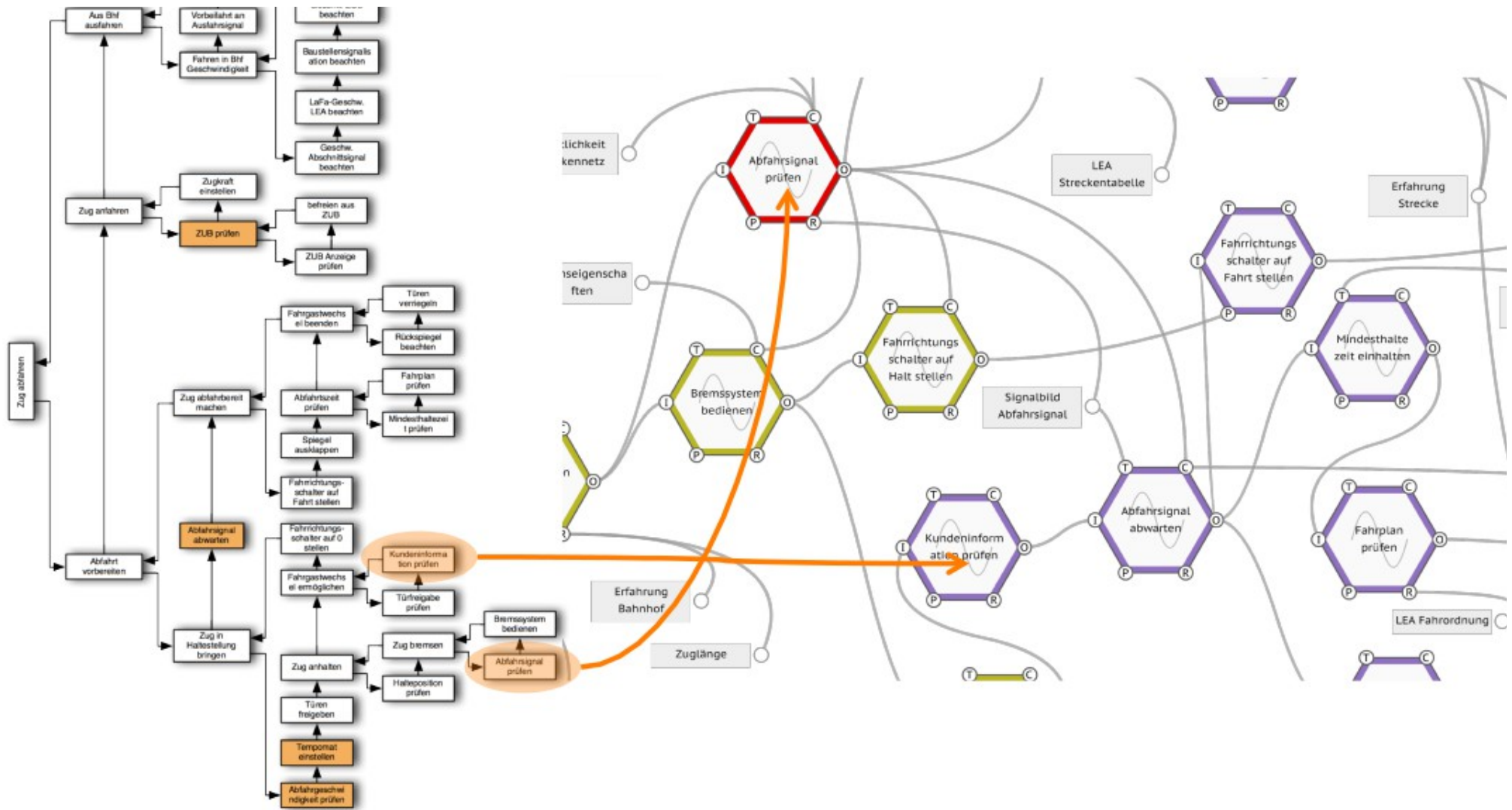
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**PURPOSE:** A FRAM analysis aims to identify how the system *functions* (or *should function*) for everything to succeed (i.e., everyday performance), and to understand how the variability of functions alone or in combination *may affect* overall performance.

**MODEL:** A FRAM model describes a system's functions and the *potential* couplings among functions. The model does not describe or depict an actual sequence of events, such as an accident or a future scenario.

**INSTANTIATION:** A concrete scenario is the result of an *instantiation* of the model. The instantiation is a “map” of how functions are coupled, or may become coupled, under given – favourable or unfavourable - conditions.

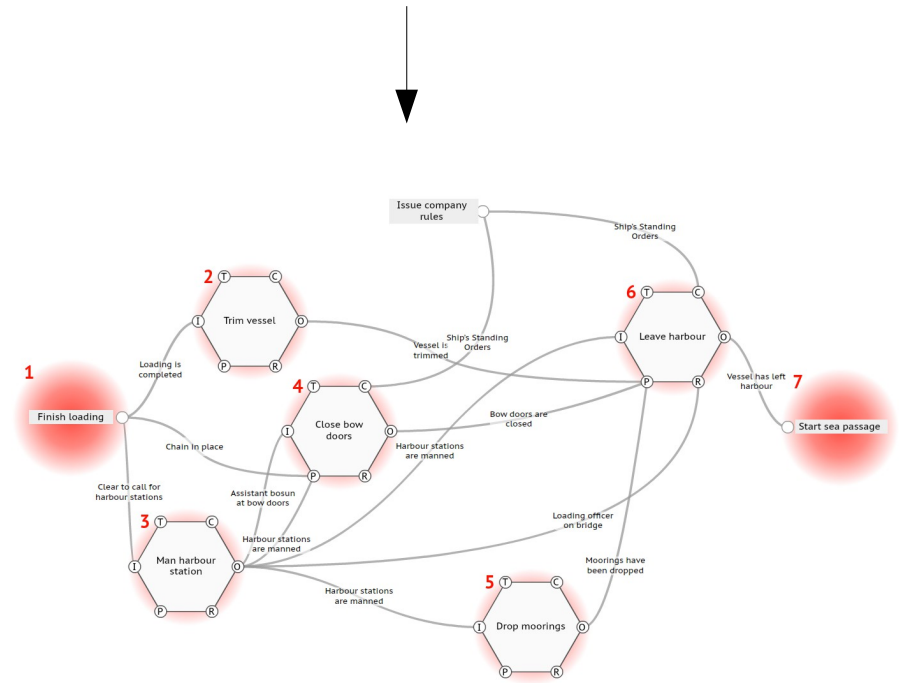
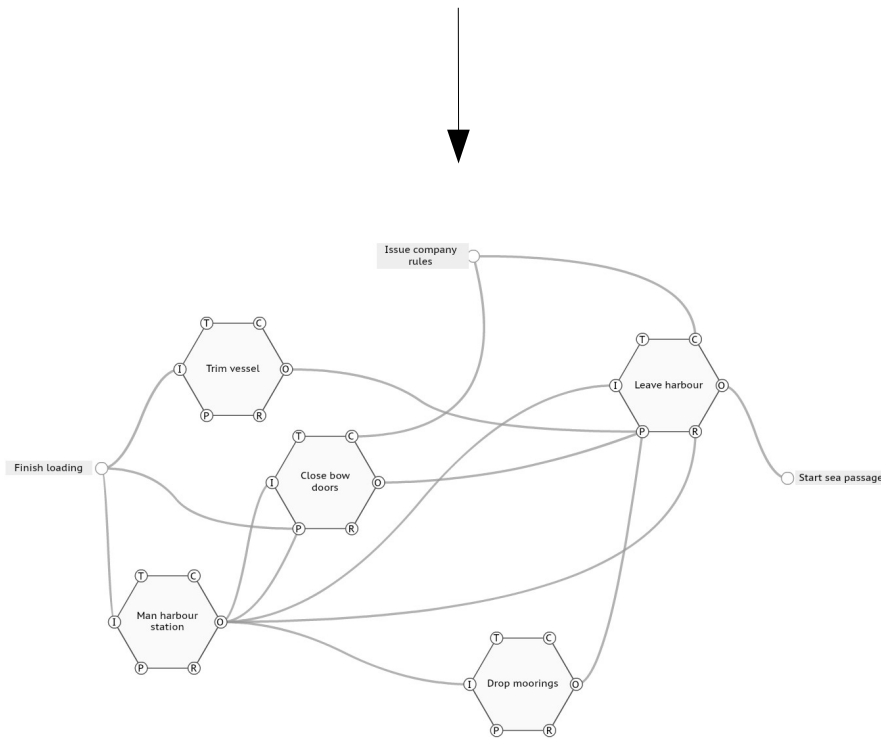
# HTA to FRAM



# Model and instantiation

Potential couplings among functions

Actual upstream-downstream couplings under given conditions

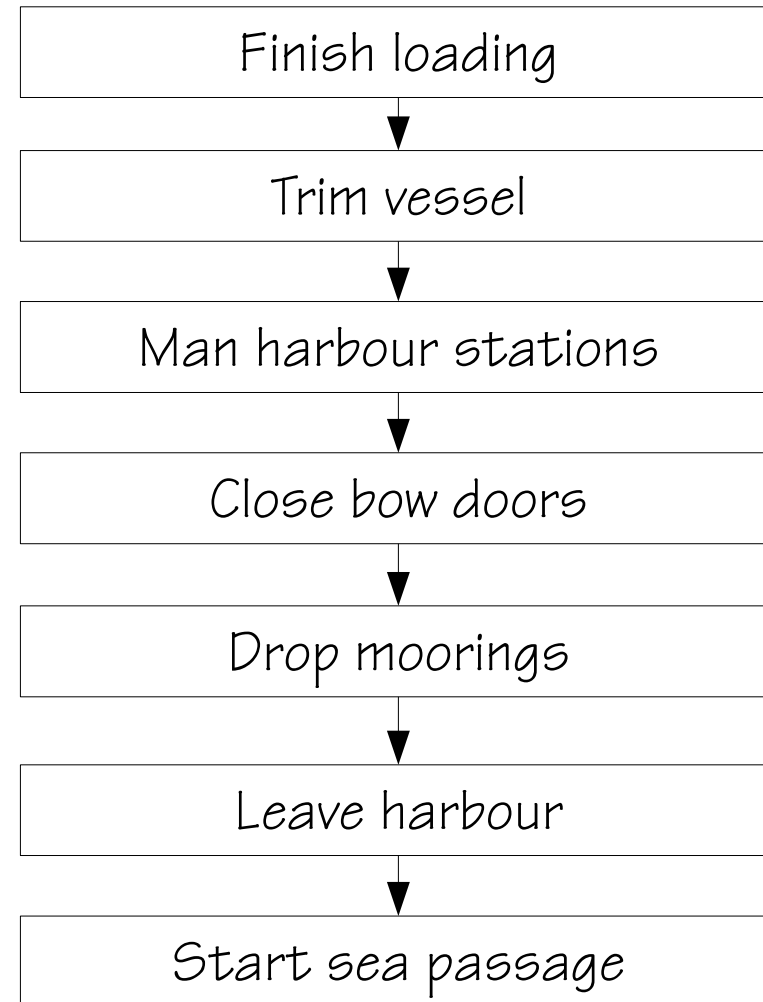


**Model**

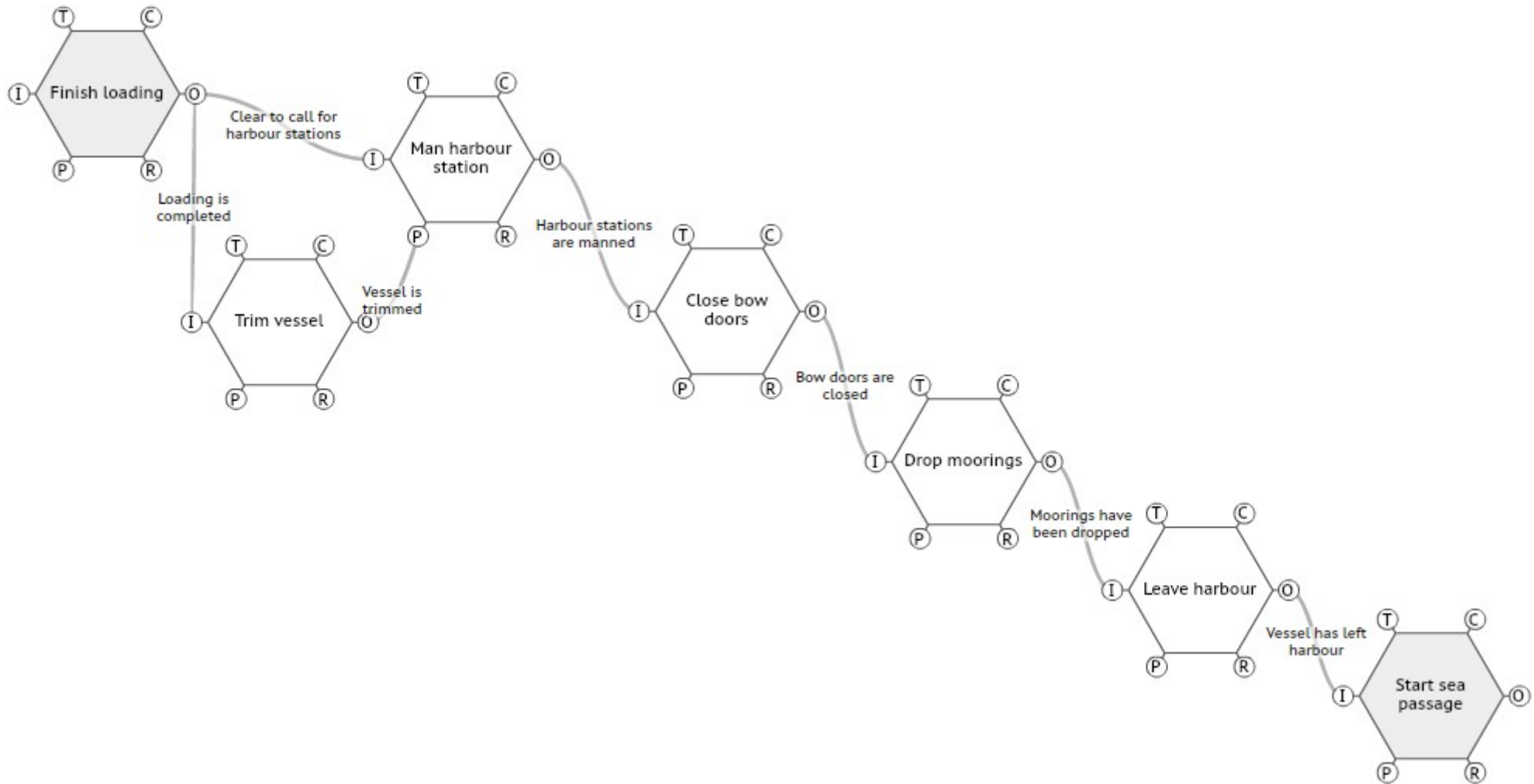
**Instantiations**



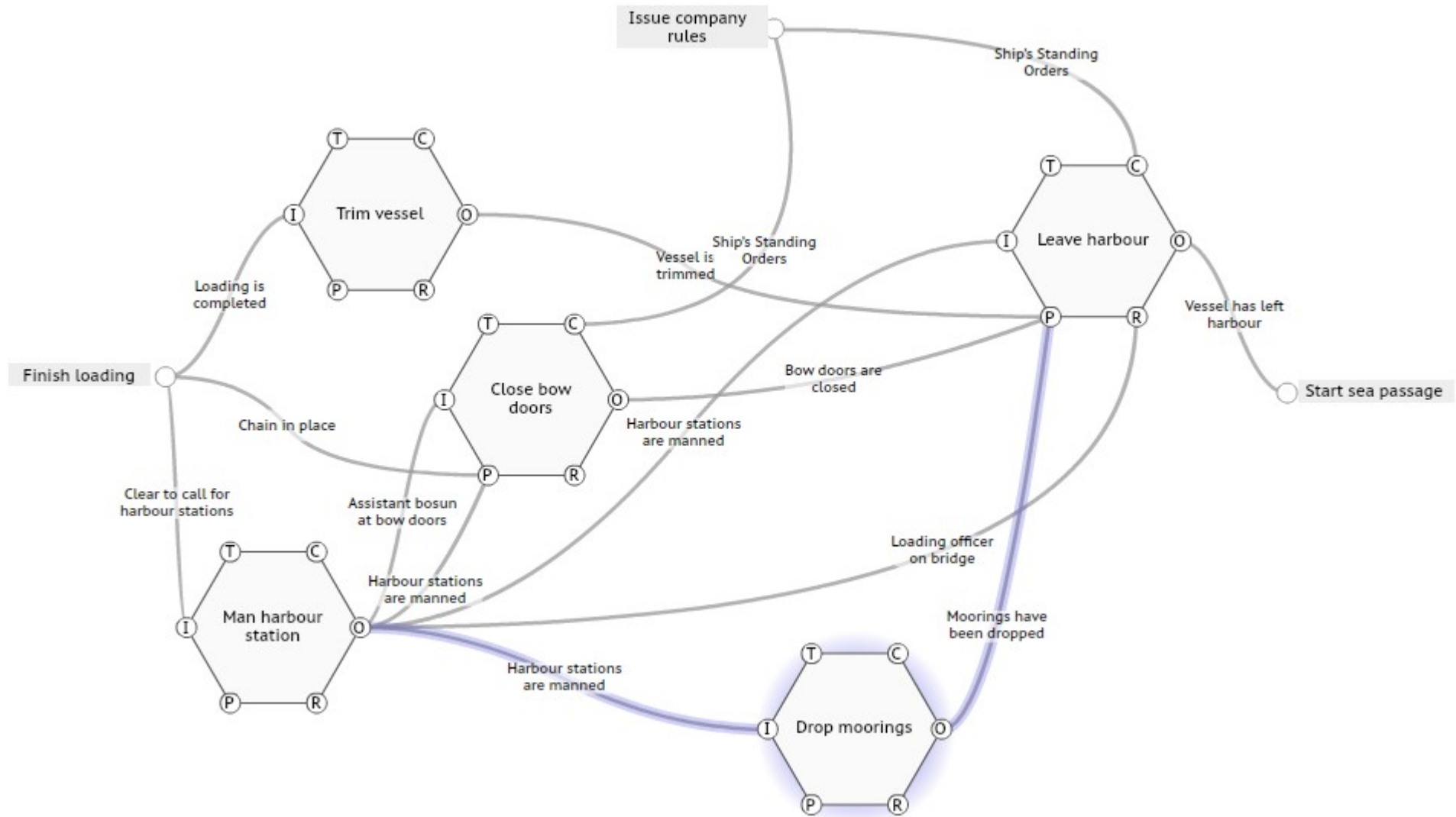
# “Herald” as a flow model (“classical”)



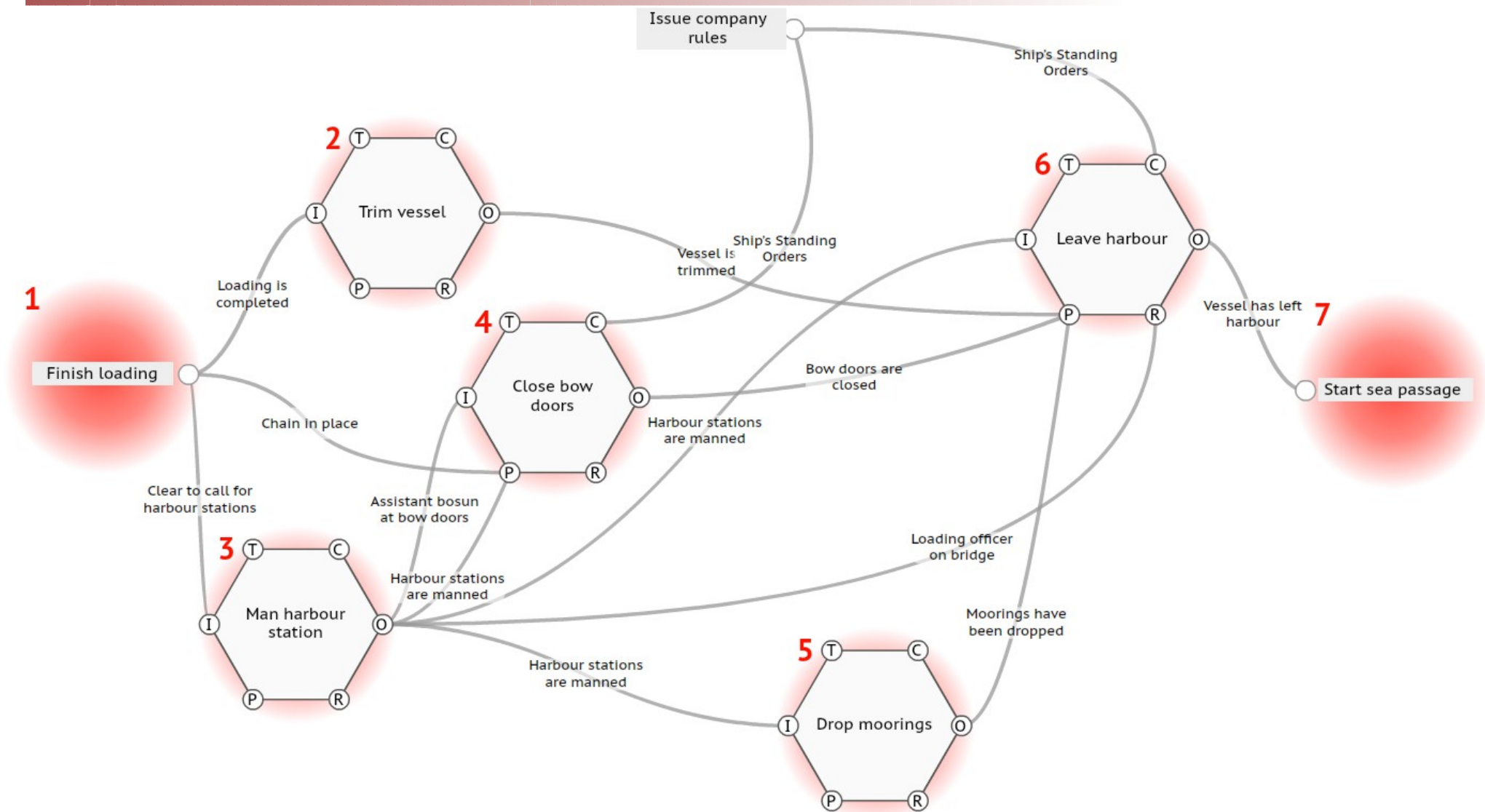
# “Herald” as a flow model



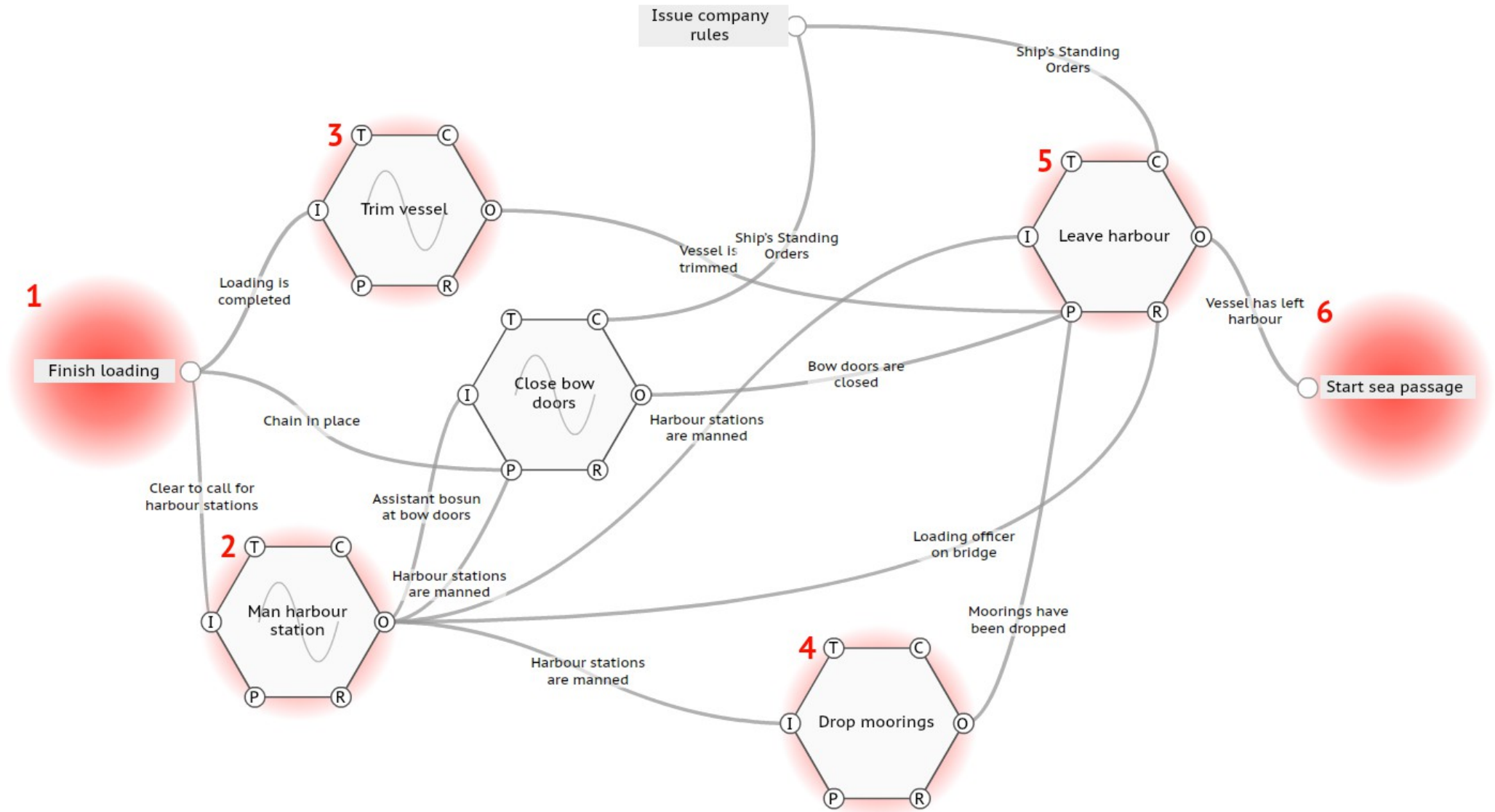
# “Herald” as a functional model



# An instantiation (normal departure)



# An instantiation (bow doors open)



# Summary

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The FRAM is a method to build a model.

The FRAM provides the basics for build a model of an activity (functions, aspects) but makes no assumptions about the activity or the model.

A FRAM model represents the potential couplings among functions in a system – the functions needed to carry out a given activity. The model is built by defining functions and their aspects, rather than by drawing them.

A FRAM model can be used to produce specific instantiations. The instantiations will show which of the potential couplings become actual couplings under given conditions.

A FRAM model can be used to support:

- Investigation of events (accident analysis)

- Consequences of changes (risk assessment)

- Analyses of work-as-done (representations of work-as-done)

- Etc., etc.